

Important implications for civil defense lie in this study of 6,343 case histories of radiation injuries, flash burns, lacerations, and contusions—received outdoors or indoors within a 2.3-mile radius of ground center.

Atomic Bomb Injuries Among Survivors in Hiroshima

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THE PRIMARY PURPOSE of this paper is to present the results of a study of atomic bomb injuries in relation to the type of protection of survivors who were at varying distances from the ground center of the explosion in Hiroshima, Japan, on August 6, 1945. An analysis has been made of the clinical histories of 5,136 injured persons and interviews with 1,207 uninjured persons exposed to the bomb. These histories and records of interviews were collected by physicians of the Joint Army-Navy Commission which investigated the medical effects of the bomb within a few months after the explosion (1).

Limitations of the Data

It is recognized that no statistical study of the types of injury incurred as a result of the

atomic bombing in Hiroshima can be fully representative of those actually sustained in that city. Authorities agree that no accurate count of the exact number of dead and injured will ever be possible and that causes of death in the areas of greatest destruction can only be estimated. Since the individuals in our study include only those who survived the disaster and were able to escape from the damaged areas of the city alone or with assistance of others, the distribution and severity of injuries in this group may be expected to differ from estimated causes of immediate death.

The total population of Hiroshima at the time the bomb was dropped and the number of injured survivors have been variously estimated. One such estimate (2) places the population figure at 245,000 with equal numbers—70,000 to 80,000 each—injured and killed, or missing and presumed to be dead. If these figures may be regarded as reasonably accurate, our study comprises a maximum 7.3 percent sample of injured survivors and 1.1 percent of the uninjured—a figure of 98,265 exposed individuals residing in Hiroshima in 1950 was obtained from the Atomic Bomb Casualty Commission's survivor questionnaire, circulated with the Japanese national census of October 1, 1950 (3).

Some bias may exist in our sample, because of the fact that many survivors, both injured

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and uninjured, left the city soon after the bombing, and the fact that an unknown number of the injured may have died elsewhere. However, an indication that many of those who fled the city had returned by the time of the interviews is afforded by the fact that the population of Hiroshima had reached 137,000 by November 1, 1945.

A long-range followup of the effects of the detonations on survivors and their descendants may alter some of the data as to actual distance of survivors from the ground center of the explosion. It is possible that the earlier interviewers' estimates of distances at specified locations reported by those interviewed were calculated hurriedly or without the aid of detailed maps which were available to later investigators.

On the other hand, persons interviewed immediately or within a short time after may have given a more nearly accurate description of their positions at the time of the bombing than at subsequent interviews when accounts given by other exposed individuals might have come to be identified as their own experiences. For this reason and also because no similar data based on the interviews by the Joint Army-Navy Commission appear to have been published, it was considered desirable to study the types of injuries in relation to the distances and the type of shelter or lack of shelter afforded the survivors.

A recent semiannual report of the Atomic Bomb Casualty Commission (4) states that "1,009 individuals surviving under 1,000 meters

and 9,191 between 999 and 1,499 meters were located during the Japanese national census in 1950." The Joint Army-Navy Commission sample includes 816 persons who were recorded as being within 1,000 meters from ground center of the explosion, 306 of whom died after admission to hospitals. At the distance of 1,001 through 1,500 meters, the sample shows 1,134 persons, 1,081 of whom were living several weeks to months after the bombing.

General Characteristics of the Sample

The total case records included in this study number 6,343. These include 5,136 injured persons, 384 of whom died in hospitals where their histories were obtained, and 1,207 who were uninjured. All these persons reported that they were within a radius of 13,120 feet from the ground center of the explosion. Not included in the study are a small number of uninjured persons within this distance who were in tunnels or air raid shelters and 229 who were at distances ranging from 13,121 to 16,400 feet from ground center.

The distance, in feet, of the injured and uninjured persons from the ground center of the explosion is shown in table 1. The percentages of uninjured persons increased with increasing distance from ground center as would be expected. The 5,136 injured persons comprise 81 percent of the total.

Four types of protection, or lack of protection, were coded by the original investigating groups and tabulated in relation to the 6,343 persons

Table 1. Injured and uninjured persons in Hiroshima sample study in relation to distance from ground center of explosion

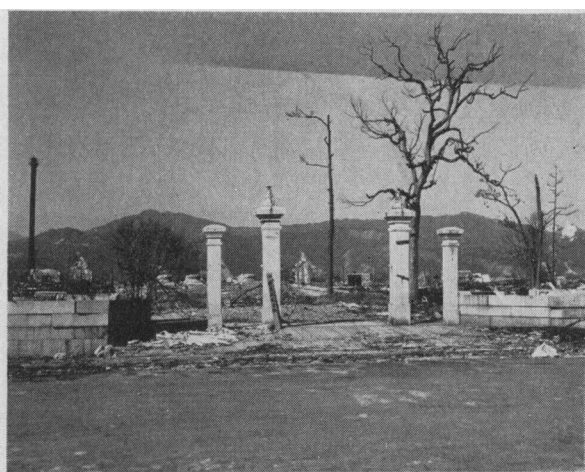
Distance (in feet)	Total	Injured				Uninjured	
		Alive		Dead		Number	Percent
		Number	Percent	Number	Percent		
3,280 or less.....	816	500	61	306	38	10	1
3,281-6,560.....	2,844	2,465	86	74	3	305	11
6,561-9,840.....	2,122	1,564	74	¹ 4	(²)	554	26
9,841-13,120.....	561	223	40	-----	-----	338	60
Total.....	6,343	4,752	75	¹ 384	6	¹ 1,207	19

¹ Includes 1 dead, no injury recorded.

² Less than 0.5 percent.



Armed Forces Institute' of Pathology photographs



Government Prefectural Office before and after the explosion occurring August 6, 1945 (2,952 feet).



Communications building (4,592 feet). General view looking away from the center.



An example of destruction of wooden buildings by the A-bomb explosion at a point 13,120 feet from the center of the explosion. Photograph was taken at 8:00 a. m. August 10, 1945.

for whom these data were obtained. These categories are: (a) outdoors and unshielded, (b) outdoors, shielded, (c) indoors in buildings of light construction, defined for convenience as Japanese-type buildings, and (d) indoors in heavy buildings of reinforced concrete, some of which were earthquake resistant, and steel frame industrial buildings.

A total of 2,690 persons, 42 percent of those in our series, were recorded as being out of doors at the time of explosion. More than three-fourths of these, 2,040 persons, were presumably not protected by any type of shelter; the remainder were shielded chiefly by buildings.

Of the 3,653 persons (58 percent of those in this series) who were indoors, approximately 89 percent, 3,249 persons, were in buildings of light (Japanese-type) construction, and the remaining 11 percent were in heavy buildings.

This low percentage of survivors who were in heavy buildings may have been due both to the fact that comparatively few heavy buildings were in the area of greatest destruction and to the crushing or pinning of persons in such buildings by heavy beams or falling plaster, with death by fire following almost immediately.

The United States Strategic Bombing Survey reported that (2), "the entire heart, the main administrative and commercial as well as residential section, was gone. In this area only

about fifty buildings, all of reinforced concrete, remained standing. All of these suffered blast damage and all save about a dozen were almost completely gutted by fire; only five could be used without major repairs."

The destruction of buildings in the urban area was officially announced by Japanese authorities as 62,000 of a total of 90,000, or 69 percent, with another 6,000, or 6.6 percent, severely damaged (5). The area of severe damage by fire was about 4.4 square miles (6).

Only 47 of the 1,207 uninjured persons interviewed were in heavy buildings at the time the bomb exploded (table 2). Forty-nine of the 404 survivors, or 12 percent, who escaped from heavy buildings died after being hospitalized, as compared with 335, or 6 percent, of the persons in other locations.

Types of Injury Indoors and Outdoors

Only three types of injury were encountered in the survivors interviewed:

More than one-half of 5,136 injured persons had mechanical injuries.

These injuries consisted of lacerations and contusions caused by flying glass and debris, falling walls, plaster, and other materials. No fractures were reported. This absence of fractures is explained in a report of Liebow, War-

Table 2. Type of protection in relation to physical status of persons exposed to the atomic bomb in Hiroshima

Type of protection	Total		Injured				Uninjured	
			Alive		Dead			
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Outdoors: ¹								
Unshielded.....	2, 040	76	1, 754	79	74	80	212	55
Shielded.....	650	24	460	21	18	20	172	45
Total.....	2, 690	100	2, 214	100	92	100	384	100
Indoors: ²								
Japanese-type building.....	3, 249	89	2, 230	88	243	83	776	94
Heavy building.....	404	11	308	12	49	17	47	6
Total.....	3, 653	100	2, 538	100	292	100	823	100
Grand total.....	6, 343		4, 752		384		1, 207	

¹ Percent outdoors, 42.

² Percent indoors, 58.

Figure 1. Percentage of injured persons with radiation, mechanical injury, and burns

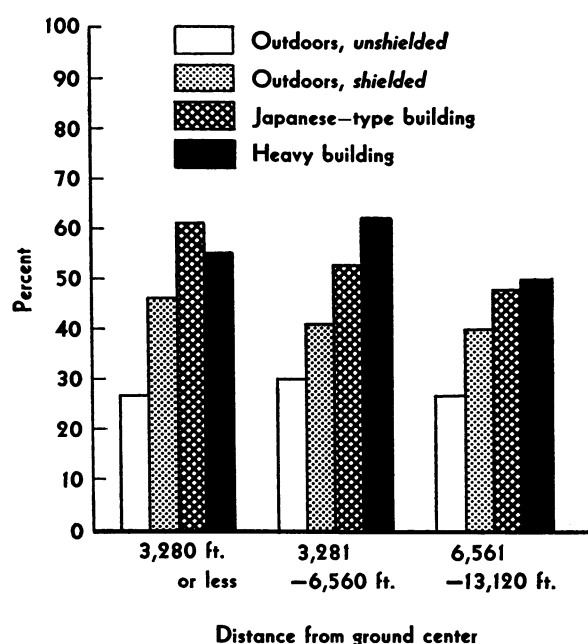
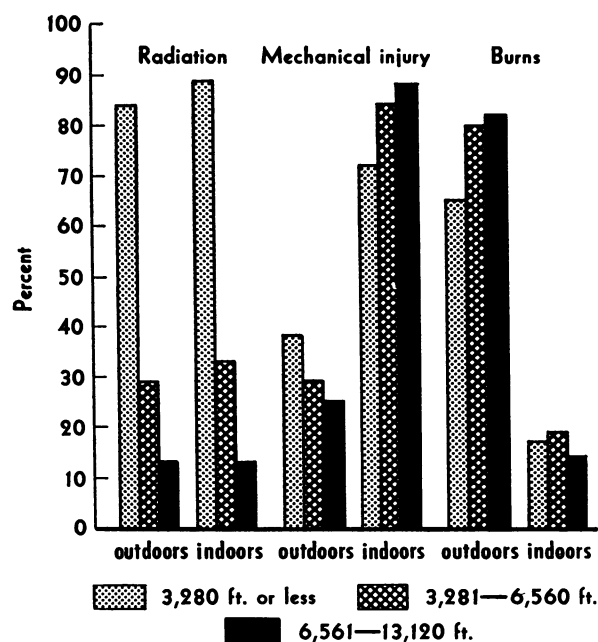


Figure 2. Percentage of persons with mechanical injuries whose injuries were severe



ren, and DeCoursey (7), which states that among survivors seen in Hiroshima 2 months after the bombing, the incidence of fractures was less than 4.5 percent—not because such injuries were few but rather that almost none who had lost the capacity to move escaped the flames.

Forty-five percent of the injured persons had burns.

All except 3 of these were the result of thermal radiation, although 8 persons with flash burns also had flame burns from clothing which ignited. Investigation indicated that the majority of the flash burns, as well as all the flame

burns, were of second or third degree, and usually were confined to the extremities. Support of this observation concerning survivors is found in the report of the Tokyo Army Medical College (8), which states:

“The degree of burn might be expected to be relative to the distance and presumably those near bombing center should be of greater degree. But it was a fact that survivors near the center of bombing had either no burns or burns of small areas. Investigation of the survivors failed to reveal any relation between the degree of burns and the distance from the center.”

Table 3. Incidence of injuries of 5,136 persons injured by the atomic bomb in Hiroshima in relation to location at time of bombing

Type of injury	Total	Outdoors		Indoors	
		Number	Percent ¹	Number	Percent ¹
Total injured.....	5, 136	2, 306	45	2, 830	55
Mechanical injury, alone or with other injuries.....	2, 977	643	28	2, 334	82
Radiation, alone or with other injuries.....	1, 732	633	27	1, 099	39
Burns, alone or with other injuries.....	2, 322	1, 846	80	476	17

¹ Percentages in this table add to more than 100 since many persons had more than 1 type of injury.

Table 4. Location and type of protection and distance from ground center of explosion in relation to incidence of injuries ¹

Location and protection	Total injured	Percent of injured with—		
		Radiation	Mechanical injury	Burns
3,280 feet or less				
Outdoors:				
Unshielded.....	128	82	28	76
Shielded.....	62	88	55	43
Indoors:				
Japanese-type building.....	471	92	70	15
Heavy building.....	145	77	80	22
3,281-6,560 feet				
Outdoors:				
Unshielded.....	922	27	20	91
Shielded.....	290	39	59	47
Indoors:				
Japanese-type building.....	1, 139	34	84	19
Heavy building.....	188	24	87	19
6,561-13,120 feet				
Outdoors:				
Unshielded.....	778	12	19	90
Shielded.....	126	17	59	43
Indoors:				
Japanese-type building.....	863	13	87	14
Heavy building.....	24	17	88	13

¹ Percentages add to more than 100 since many persons had more than 1 type of injury.

Effects of radiation were encountered in 34 percent of the injured persons.

As would be expected among individuals who survived for several weeks or months, the radiation was more often described as moderate than as severe. We have previously reported that 18 survivors who were reported as outdoors and unshielded within 3,280 feet of ground center had symptoms indicating only moderate radiation sickness (9).

No blast injuries were noted in the persons seen by the Joint Commission physicians, nor, according to the Tokyo Army Medical College (8), were there many survivors with internal

injuries and blood vessel injuries. The possibility of death from central nervous system injury resulting in pulmonary edema and hemorrhage among persons in close proximity to walls or the ground in cases where the blast would strike the surface square on is suggested by Cas- sen, Kistler, and Mankiewicz (10), on the basis of experimental data.

The breakdown of injuries by location (table 3) shows that mechanical injuries occurred in 82 percent of the injured survivors who were inside buildings as compared to 28 percent of those who were outdoors. In contrast, flash burns were reported for 17 percent of the survivors indoors and 80 percent of those outdoors. Radiation effects were noted chiefly among survivors near the ground center, where gamma rays penetrated buildings and where instantaneous deaths from massive radiation may have occurred among persons unprotected by buildings. This may account for the higher percentage of radiation injury among survivors indoors than among those who were outdoors.

The incidence of injuries among injured survivors at different distances from ground center is considered with respect to type of protection

Table 5. Types of single and multiple injuries of 5,136 injured persons

Type of injury	Total	Distance from ground center (feet)		
		3,280 or less	3,281–6,560	6,561–13,120
Total injured.....	5,136	806	2,539	1,791
Percent of total				
Mechanical:				
Alone.....	33	8	33	43
With radiation.....	14	42	13	4
With burns.....	7	2	8	8
With both.....	4	11	4	1
Total.....	58	63	58	56
Burns:				
Alone.....	27	3	27	36
With radiation.....	7	12	9	3
Total.....	34	15	36	39
Radiation alone.....	8	22	6	5

Table 6. Location, type of shelter, and distance from ground center of explosion in relation to type of injury

Location and shelter	Total (100 per- cent)	Percent in group						Burns alone
		Mechanical injury				Radiation		
		Alone	With burns	With radia- tion	With burns and radia- tion	Alone	With burns	
3,280 feet or less								
Outdoors:								
Unshielded	128	1	4	9	14	14	45	13
Shielded	62	7		29	19	21	19	5
Indoors:								
Japanese-type building	471	6	2	53	9	26	4	(1)
Heavy building	145	19	3	43	15	16	3	1
3,281-6,560 feet								
Outdoors:								
Unshielded	922	5	9	2	4	2	19	59
Shielded	290	29	9	15	6	9	9	28
Indoors:								
Japanese-type building	1, 139	53	7	21	3	7	3	5
Heavy building	188	61	9	14	3	6	1	6
6,561-13,120 feet								
Outdoors:								
Unshielded	778	7	9	1	2	3	6	72
Shielded	126	41	10	8		8	1	32
Indoors:								
Japanese-type building	863	75	6	6	1	5	1	6
Heavy building	24	71	8	8		8		5

¹ Less than 0.5 percent.

or lack of protection in table 4 and for the percentages outdoors and indoors in figure 1. Radiation injury was found generally unrelated to type of protection, and there was rapid fall-off from the first distance zone outward.

Mechanical injuries were definitely related to the amount of protection afforded. Whereas no more than 28 percent of the survivors who were outdoors and unshielded in any distance zone had such injuries, the percentages with mechanical injuries who were indoors in heavy buildings ranged from 80 to 88 percent. Of interest also are the statistically significant higher percentages of mechanical injuries among persons injured outdoors in each zone who were presumably "shielded" than among those outdoors and unshielded.

The highest incidence of burns occurred in the second distance zone and beyond. Forty-

eight percent of all the injured survivors at 3,281-6,560 feet and from this zone outward had burns, as compared with 28 percent of those nearest ground center. (Burns occurred in only 17 percent of the victims at the 9,841 to 13,120 feet distance.) However, 76 to 91 percent of the injured survivors outdoors and unshielded in each distance zone incurred flash burns. Any form of protection decreased the percentages with burns.

A breakdown of the injuries into single and multiple types revealed that while two-thirds of the injured survivors had only 1 form of injury, this was not true of those within 3,280 feet of ground center, where 67 percent had multiple injuries. The types of injuries, alone and in combination, are presented in table 5. Here, by addition of the percentages, it is evident that 87 percent who were within the first

3,280 feet had radiation, but it was the sole injury for only 22 percent. The most frequent combination at this distance was radiation with mechanical injury—in 42 percent. Many such patients who received therapy were treated for their mechanical injuries only, since the effects of radiation were not immediately manifest. The influence of various kinds of protection or the lack of protection upon the types of injuries sustained is demonstrated in table 6.

Physicians of the Joint Army-Navy Commission assigned ratings of "severe" or "moderate" to the types of injuries described by the survivors whom they actually interviewed. Similar ratings were not made for the seriously injured persons who died in hospitals. The relative severity of the nonfatal injuries within the first 3,280 feet from ground center, which is of particular interest, is shown in table 7. Symptoms indicating severe radiation occurred in 57 percent of the 510 survivors not fatally injured in this zone, and in 66 percent of those who were outdoors and presumably shielded by walls or other objects. Severe radiation among such survivors in Japanese-type buildings was approximately the same as for those outdoors

and shielded, 64 and 66 percent, respectively. Thirty-eight percent of those in heavy buildings also had severe radiation injury.

Mechanical injuries which were considered severe occurred with approximately equal relative frequency in Japanese-type and in heavy buildings in this first zone.

Mechanical injuries were considered as the most severe type of injury sustained by 1,396 of the 2,826 persons who had this type of injury. As shown in table 8, the severe mechanical injuries in each distance zone increased with increasing protection and were incurred in approximately one-half to two-thirds of the injured persons who were indoors in buildings of either light or heavy construction.

Summary

Data pertaining to 6,343 survivors (5,136 injured and 1,207 uninjured) of the atomic explosion in Hiroshima on August 6, 1945, are analyzed with respect to the incidence of mechanical and radiation injuries and flash burns, in relation to distance from ground center and type of protection. The data were based on

Table 7. Percent of injured persons with moderate or severe nonfatal ¹ injuries, 3,280 feet or less from ground center of explosion, Hiroshima

Type and severity of injury	Percent of total injured ² (510 persons)	Type of protection			
		Outdoors		Indoors	
		Unshielded (84 persons)	Shielded (47 persons)	Japanese-type building (276 persons)	Heavy building (103 persons)
Burns, flash.....	21	63	35	12	7
Moderate.....	17	49	31	10	7
Severe.....	4	14	4	2	
Burns, flame.....	. 2			. 4	
Moderate.....	. 2			. 4	
Severe.....					
Burns, not specified as to type or severity.....	7	18	11	5	2
Mechanical.....	69	29	53	80	82
Moderate.....	27	22	28	28	32
Severe.....	42	7	25	52	50
Radiation.....	85	86	89	89	68
Moderate.....	20	33	15	16	21
Severe.....	57	50	66	64	38
Questionable.....	8	3	8	9	9

¹ Excludes 296 persons who died in hospitals shortly after the explosion.

² Percentages in this table add to more than 100 since many persons had more than 1 type of injury.

Table 8. Persons with mechanical injuries, by location and type of protection ¹

Location and type of protection	Mechanical injuries		
	Total	Severe	Percent severe
3,280 feet or less			
Outdoors:			
Unshielded	33	9	27
Shielded	30	17	46
Indoors:			
Japanese-type building	308	187	61
Heavy building	110	68	55
3,281-6,560 feet			
Outdoors:			
Unshielded	176	53	30
Shielded	168	69	41
Indoors:			
Japanese-type building	909	482	53
Heavy building	164	102	62
6,561-13,120 feet			
Outdoors:			
Unshielded	143	38	27
Shielded	73	29	40
Indoors:			
Japanese-type building	690	331	48
Heavy building	22	11	50

¹ This table omits the records of 85 autopsied persons since the severity of injury was not recorded by the physicians.

histories and interviews obtained by physicians of the Joint Army-Navy Commission which investigated the medical effects of the atomic bombs in Japan within a few months after the explosions. Pertinent observations are these:

All the exposed persons were within 13,120 feet from ground center of the explosion; 816 were within 3,280 feet; 2,844, from this distance through 6,560 feet; 2,122, from 6,561-9,840 feet; and 561, from 9,841 through 13,120 feet. These were survivors who were able to escape from the area of greatest damage either alone or with a minimum of assistance.

Forty-two percent of the exposed persons were reported as being out of doors at the time of the explosion, and 2,040, or 76 percent, of these were presumably not shielded and so were exposed to the full effects of the explosion.

The majority (3,249) of the 3,653 persons who were reportedly indoors were in buildings of light or Japanese-type construction, and 404 were in buildings of heavy construction.

The percentages of persons who were uninjured increased with increasing distance from ground center. Only 47 of the 1,207 uninjured persons interviewed stated that they were in heavy buildings at the time of the explosion.

Mechanical injuries (lacerations and contusions) were by far the most common type of injury, occurring in 58 percent of the injured, 82 percent of those who were indoors, and 28 percent of those outdoors.

Burns (flash burns in 2,311 and/or flash and flame burns in 11 instances) occurred in 45 percent of the injured survivors; in 17 percent of those indoors as compared to 80 percent outdoors.

Radiation injury, recorded for 34 percent of the injured survivors, occurred chiefly among those who were within 6,560 feet of ground center. The overall percentages of those indoors and outdoors with radiation effects were 39 and 27, respectively.

Although two-thirds of the injured survivors had only 1 type of injury, the same fraction of those within 3,280 feet of ground center had multiple injuries. Radiation was by far the most common injury in this first distance zone.

When the type of protection or lack of protection was considered, it appeared that mechanical injuries were noted more frequently among survivors in buildings than among those who were outdoors, and significantly more often in the relatively few survivors who had been in heavy buildings than among the large number who were in the Japanese-type structures. At a distance within 3,280 feet, 63 percent of the injured persons had mechanical injuries, in conjunction with radiation, burns, or a combination of both in 55 percent. Beyond this distance, the majority of those with mechanical injuries had no other type of injury.

Mechanical injuries classified as the most severe of the injuries sustained were noted more often for survivors in buildings and those outdoors who were shielded to some extent than for those who were entirely unprotected from the effects of the explosion.

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FDA Tolerances for Food Crop Pesticides

Procedural regulations issued by the Food and Drug Administration, Department of Health, Education, and Welfare, under the new pesticide amendment to the Federal Food, Drug, and Cosmetic Act went into effect March 6, 1955.

Under the new law, which becomes fully effective July 22, 1955, one year following its enactment, unless extended, food shipments bearing residues of pesticide chemicals in excess of established tolerances will be contraband and subject to seizure as adulterates.

Protection of the public under the law with a minimum of legislation is the aim of the Food and Drug Administration, hence, regulations establishing procedures for determining safe tolerances for pesticide chemicals were published in the *Federal Register*, February 4, 1955, pp. 770-771. However, petitions from chemical manufacturers have been processed according to the terms of tentative regulations published October 20, 1954, and the final regulations will not affect the petitions so processed. Any action taken in compliance with the tentative regulations will be regarded as complying with the law.

The final form of the procedural regulations differs from the tentative regulations principally in the following particulars:

1. A time limit of 15 days is established within which FDA must notify a petitioner of acceptance or nonacceptance of his petition.

2. Rewording makes it clear that a firm need submit a set of toxicity data to FDA only once.

3. An incomplete petition may be filed if the petitioner insists upon it.

4. A petition may be filed before a sample requested by FDA has been furnished.

5. Rewording provides a more definite time limit for consideration of a petition or request by an advisory committee.

6. The fee provisions of the regulation are changed to result in a more equitable assessment of the costs of the service. (The total cost of the service to the pesticide industry is now estimated to be slightly less than the original estimate.)

Regulations fixing tolerances for 28 pesticides that were in common use prior to the passage of the new law are still being reviewed by the Food and Drug Administration.